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Macroeconomic Effects of Price Shocks: A Simulation Study

RESPONSIBILITY for the high rate and acceleration of general price inflation in the United States that characterized most of the last decade, as well as for declines in real economic activity, has often been attributed to a large extent to accelerations of primary commodity prices.[1][2] Frequently, surges in such prices stemmed from abrupt changes is supply conditions. Well-known examples are the price explosions that accompanied or followed the shortfalls in the supplies of grain and other foodstuffs in 1972–73 and OPEC's curtailments of crude oil production in 1973–74 and 1978–80. Price responses, whether they result from the impersonal mechanism of the market or from decisions by members of a cartel, are the natural concomitants of these "supply shocks" and tend to clear the market under the new supply conditions.

Other commodity price increases resulted from "demand shocks." For example, prices of nonferrous metals rose sharply in 1972–73 in the wake of simultaneous upswings in the business cycle in the industrial nations, while increases in the productive capacity for many of these metals were limited.

A third class of price shocks, not precipitated by either supply or demand shocks, may be called "insti-

tutional" price shocks. They are the result of (public or private) policy decisions. Recent examples were the introduction and subsequent removal of general price and wage controls in 1971–74 and the decontrol of domestic crude oil during 1978–81.

In conventional macroeconometric models, which are essentially demand-driven, supply shocks (with market-clearing price responses) and institutional price shocks are handled in the same way. From the standpoint of the model—as from that of buyers in actual markets—these two kinds of shocks are basically indistinguishable, both appearing as price shocks. Thus, in order to incorporate them into a model simulation or forecast, it is usually necessary first to translate them into their mirror-image price shock.[3]

A demand shock, unlike a supply shock, can usually be incorporated as an explicit model input. A shift in demand can be represented by such variables as a change in sales, orders, inventories, or capacity utilization; the resulting price change is an endogenous response. Of course, if the demand shock originates abroad and does not impinge primarily on U.S. exports, the resulting change in world commodity prices is, from the U.S. point of view, again a purely exogenous price shock.

Previous studies of price shocks have largely concentrated on prices of energy and food. This article, in con-

trast, analyzes and compares short- and medium-term effects on major macroeconomic variables of a broad variety of price shocks as estimated from simulations with the BEA quarterly econometric model. More specifically, the prices subjected to shocks include prices of both primary commodities (or "basic materials") and final products.[4] The variables affected include GNP, major GNP components, the GNP and personal consumption expenditures implicit price deflators, shares of national income by type of income, the unemployment rate, and interest rates. In all but one of the cases—an increase in farm product prices—the cause of the shock (i.e., whether a supply or a demand shift or a policy decision) is not specified; rather, the shock is treated as an exogenous price change.

The simulations are highly stylized rather than faithful representations of the real world, so that one can derive useful generalizations. However, approximations to realistic cases can often be made by appropriate interpolation or extrapolation. On the basis of this study, two generalizations can be made concerning the effects of price shocks: (1) The effects on real GNP and unemployment, as well as on the general price level, are usually strong; and (2) the magnitudes of these effects differ substantially among different types of shocks and are also sensitive to the economic and monetary policy environments in which they occur.

The first section of the article outlines the structure of the price-wage sector of the BEA model to provide the necessary background for understanding the mechanisms involved in

1. See, for example, Otto Eckstein, *Core Inflation* (Englewood Cliffs, N.J.: Prentice Hall, 1981) and Barry P. Bosworth and Robert Z. Lawrence, *Commodity Prices and the New Inflation* (Washington, D.C.: The Brookings Institution, 1982).

2. "Primary commodities" consist of crude materials (such as crude oil, foods and feeds, and iron ore) and materials that have passed through initial stages of processing (such as wood products and fibers).

3. Conventional models often do contain certain breakdowns of production sectors, with outputs as well as prices of these sectors feeding back into the main sector. The farm sector in the BEA quarterly econometric model, which is used in the simulations described in this article, is of this type. Indeed, one of the price shock cases to be analyzed in this article stems from an assumed shortfall of farm output; in that case, both output and price variables explicitly affect the overall model results.

4. The distinction between "primary commodities" and "basic materials" is explained below.

the price-shock simulations.[5] The second section describes the general methodology used in the simulations and the cases for which simulations were run. The final section presents and analyzes the results.

The Price-Wage Sector: An Overview

In the BEA model, prices—or more precisely, implicit price deflators (hereafter referred to as "deflators"), as defined in the national income and product accounts (NIPA's)—are largely determined in a "stage-of-processing" framework. Producer prices of energy and farm products and prices of imported commodities are exogenous.[6] Together with wage rates or unit labor costs and demand pressure variables, such as capacity utilization, the unemployment rate, or manufacturers' new orders, energy and import prices explain producer prices of five classes of "basic materials," the lowest tier of endogenous prices; the five commodity groups are primary iron and steel products, primary nonferrous metal products, nonmetallic mineral products, lumber and wood products, and primary nondurable products.[7]

Basic materials prices, along with variables (including energy prices) similar to those used in the equations for basic materials prices, in turn determine producer prices of finished consumer goods and, through the latter, deflators for corresponding personal consumption expenditures (PCE) components and for business purchases of motor vehicles. Similar equations determine (directly) deflators for nonconsumption goods purchases. In addition, the producer price index for farm products largely explains movements in the PCE deflator

for food and beverages and producer energy prices determine corresponding PCE deflators for energy products. Other equations, not involving intermediate goods prices but with the wage rate or unit labor cost playing the dominant role, explain movements in deflators for nonenergy services (except the deflator for government employee compensation, which is exogenous).

The basic wage-rate variable—the change in compensation per hour for the nonfarm business sector excluding housing—depends primarily on the inverse of the overall unemployment rate (adjusted for changes in the "high-employment" unemployment rate) and lagged changes in the PCE price deflator. The inverse form of the unemployment rate introduces an important nonlinearity into the model and is based on the assumption that in tight labor markets (reflected in low unemployment rates), wage rates respond much more sensitively to the availability of workers than in loose labor markets. Short- and long-run changes in the PCE deflator have different influences on the change in the wage rate; the short-run elasticity (i.e., up to 1 year) of the wage rate with respect to consumer prices is 0.5, while the long-run elasticity is 0.9. These graduated effects are based on the assumption that short-run changes in the inflation rate are much less firmly implanted in expectations of future inflation than are longer run changes and, accordingly, have less of an influence on wage rates. The differential also reflects the short-run fixity of union wage contracts.

Description of Model Simulations

General methodology

The analysis of price shocks in a macromodel context is essentially an adaptation of "multiplier" analysis. Multipliers measure the changes in endogenous variables that are induced by a unit change in an exogenous variable or by an exogenous change in an endogenous variable. Usually, it is such policy-determined variables as Federal expenditures, taxes (tax rates or direct receipts ef-

fects), and money supply that are the subjects of the multiplier analysis and, accordingly, are the variables that are changed exogenously.[8] For this study, it is price indexes or implicit price deflators that are "shocked" (i.e., changed), in each case by a fixed percentage, although these percentages differ for different cases, as will be explained shortly.

In linear models, multipliers are fixed parameters of the system; i.e., once such a model has been estimated, its multipliers can be directly calculated and taken to be valid under all economic environments and for different assumed amounts of exogenous change. Because most macroeconometric models, including the BEA model, are—realistically—nonlinear, such invariance does not hold; accordingly, multipliers must be determined by model simulation under specified conditions. The procedure is to run a "control" solution of the model, obtain another solution with the changed input (in the present study, the price shocks), and finally, to measure the differences between corresponding outputs of the shocked and the control solutions.

Two control solutions, each extending over a 5-year (20-quarter) period and representing different cyclical states of the economy, were utilized. In one control solution, a relatively high unemployment rate—between 7½ and 8 percent (i.e., near the midpoint of its actual range during the last 5 years)—was maintained; in the other, a relatively low rate—between 5½ and 6 percent—was maintained.[9]

5. A full description of this sector is given in Albert A. Hirsch, "A Stage-of-Processing Price Sector for the BEA Quarterly Econometric Model," BEA Working Paper 1, September 1982. (See the abstract in the SURVEY OF CURRENT BUSINESS, 62 (December 1982):10.)

6. Energy prices used in the model are the producer price indexes for coal, refined petroleum products, gas fuels, and electric power. If assumed changes in energy prices are given in terms of crude materials, such as crude oil, they must first be translated into appropriate producer prices by extraneous calculations.

7. "Basic materials" overlap but differ somewhat from "primary commodities" in that they include commodities that have undergone a substantial amount of initial processing and exclude crude materials.

8. See Albert A. Hirsch, "Policy Multipliers in the BEA Quarterly Econometric Model", SURVEY, 57 (June 1977): 50-71.

9. Each of these solutions was obtained by running the model over a historical period and modifying selected exogenous variables—mainly major fiscal and monetary policy variables—relative to actual values in order to bring the unemployment rate within the desired range throughout the simulation period. More specifically, the high-unemployment control solution was obtained by running the model over the period 1976-80; for the low-unemployment solution, the period 1978:2 through 1982:1 was used. (Exogenous variables for the latter portion of the second period are pragmatic projections, rather than realistic forecasts.) Although, from the standpoint of making comparisons, it would have been desirable to use a common period, the use of different periods was dictated by the practical requirement that in each instance, historical levels of the unemployment rate in the early quarters of the simulation period be within or near the desired range.

All of the price-shock simulations were run with the high-unemployment control solution; in one case, the low-unemployment solution was also used in order to examine the sensitivity of the results to this alteration of the economic environment.

For each shocked solution, exogenous adjustments to the relevant price indexes or deflators were made as follows. Where the shocked price index or deflator is itself exogenous, its level was set in each quarter at a fixed percentage above its corresponding control solution level. Where the price index/deflator is endogenous, adjustments were made to the intercept of the equation that explains it in order to yield a fixed-percentage increase in the price, before model feedbacks, relative to corresponding control solution levels.

For multiplier analysis in which income or product flows are shocked, it is meaningful to compare results for common dollar amounts of all shocks. The appropriate analog for price multipliers, however, involves shocks of varying sizes because different prices have different weights in terms of the proportion of GNP that is directly affected. The approach used to solve the weighting problem, and thereby to facilitate comparisons among price shocks, was to scale the size of each shock so that its "direct" effect (i.e., its effect before system feedback) on the GNP deflator is a common fixed-percentage increase.

More specifically, the size of each shock was set so as to raise the GNP deflator 1 percent above its corresponding control solution level by the fourth quarter after the introduction of shock, as a result of direct effects only.[10] Normalization in the fourth quarter allows for lags in passthroughs of intermediate goods (energy, basic materials, and farm products) prices. For a shock in the deflator for a final-demand component, the direct effect is the percent-

age increase in the deflator multiplied by the relative weight of that component in real GNP. For a shock in the price of an intermediate good, the direct effect on the GNP deflator is calculated on the basis of the passthrough of the price (i.e., cost) increase to final-product prices.[11]

Where necessary, the direct effect was sorted out from indirect (i.e., model feedback) effects by a simulation in which all the normally endogenous variables in the model except prices were exogenized. An important variable in the exogenized set is the private nonfarm sector wage rate, which accounts for most of the system feedback to prices. (In addition, certain other adjustments to eliminate inappropriate feedbacks were made.)

Ad-hoc modifications to model structure.—Certain aspects of the BEA model's structure that are not critical for most applications of the model are significantly misspecified if it is used to analyze price shocks, especially for periods longer than 2 to 3 years—the typical forecasting horizon over which the model is considered useful. Accordingly, the following special modifications to the structure were introduced for this study.

(1) Government purchases of goods and services are ordinarily exogenous in current dollars because they reflect budgetary appropriations, which are, of course, made in current dollars. In reality, however, when there are large unexpected price changes, real purchases will not be modified to compensate fully for them. Accordingly, the following assumptions were made: (a) All national defense purchases were made exogenous in real terms; i.e., real purchases are unresponsive to price shocks; and (b) current-dollar State and local noncompensation purchases were increased by one-half of the relative increase in the deflator for these purchases; i.e., the elasticity of real purchases with respect to their price was assumed to be −0.5.

(2) Federal transfer payments to persons other than unemployment in-

surance benefits, which are ordinarily exogenous, were assumed to respond to the lagged change in the Consumer Price Index (CPI) to reflect the actual indexation of most transfer payments. Specifically, social security benefits were fully indexed to the CPI and other Federal transfers were assumed to increase in the shocked solution relative to the control solution by 0.25 times the corresponding difference in the lagged CPI due to a price shock.

(3) Because there is a tendency to adjust wage rates in the government sector to comparable wage-rate changes in the private sector (although in recent years, less than proportionally), government employee compensation payments and deflators (both exogenous) were modified in the price-shock simulations by setting the percent difference from the control solution values in the compensation deflators in quarter t equal to 0.7 times the corresponding difference in private nonfarm compensation per hour in quarter $t-2$.[12]

(4) Crude adjustments were made to the foreign exchange rate in response to changes in net foreign investment and in short-term interest rates that are induced by the price shocks. The change in the value of the dollar, in turn, affects the volume of exports and the deflator for imports.

Monetary accommodation of price shocks.—The question arises what assumption should be made about monetary policy in the presence of price shocks. The assumption used for most of the simulations analyzed in this article is that monetary policy is nonaccommodating. Specifically, the M2 variant of the money supply, which is the principal exogenous monetary policy instrument in the BEA model, is held unchanged from its control solution levels in the shocked solution.[13]

The rationale for this course is that with the money supply fixed, a price shock should result (allowing suffi-

10. Although, as noted, in a nonlinear system, multipliers can vary with the size of the exogenous change, such variability is in fact small, at least over a moderate range of variation of the input. Accordingly, no simulations of larger or smaller changes in any price were prepared for this article. Similarly, experimentation showed that positive and negative price shocks of the same magnitude have approximately symmetric effects; accordingly, no instances of negative price shocks are reported.

11. Insofar as pass-throughs of energy and basic materials prices to products prices are determined by input-output coefficients, pass-throughs are constrained to be on a dollar-for-dollar basis. However, in certain equations pass-throughs are determined from regression-based estimates. Thus, one cannot be certain as to how much the system estimates of pass-throughs deviate from a strict dollar-for-dollar effect.

12. In reality, adjustments in social security benefits and Federal pay normally occur only once a year—on July 1 for the former and on October 1 for the latter. However, in keeping with the stylized nature of these simulations, these seasonal elements were not introduced.

13. M2 contains small time and savings deposits, money market funds, overnight repurchase agreements, and Eurodollar deposits, in addition to demand deposits, other checkable deposits, and currency, which define M1. M1 is endogenous in the model and is related to M2.

cient time for market participants to make adjustments) in a change in relative prices, but not in the aggregate price level or, in the long run, in the level of economic activity. This outcome would materialize, according to theory, because the exogenous price increase induces substitution by purchasers toward commodities whose prices did not initially increase (and that have, therefore, fallen in a relative sense) and away from the commodity whose price increased. This demand response, in turn, tends to reduce the price of the shocked commodity, thus partly offsetting the initial increase, and to increase the prices of the substituted commodities.

An "accommodative" monetary policy cannot be unambiguously defined. The criteria for such a policy can be specified alternatively in terms of monetary aggregates, interest rates (short-term or long-term), or measures of economic activity, such as real output or employment (or its complement, unemployment).[14] For this study, a monetary accommodation assumption was specified in terms of a monetary aggregate. Specifically, M2 was set 1 percent above the control solution levels (i.e., the levels maintained in nonaccommodating cases).[15] Alternative simulations (i.e., with accommodation) were run for the case in which the low- as well as the high-unemployment control solution was used.

The rationale for this criterion of accommodation is that if prices of commodities other than the shocked commodities are "rigid," i.e., unresponsive to demand shifts, the 1-percent increase in the money supply is just enough to satisfy the additional transactions demand for money associated with the directly generated 1-percent increase in the GNP deflator; it is not enough, however, to satisfy the additional transactions demand associated with the secondary changes in the price level (i.e., price-wage feedbacks resulting from the price shock).

With a stable velocity of money (ratio of the money supply to current-dollar GNP), there would be no change in real GNP other than that resulting from secondary price effects.[16]

Although a more accommodating criterion—for example, increasing the money supply to satisfy the additional transactions demand associated with the secondary changes in the price level—could have been used, this was not done because the intent was only to bracket the probable monetary response. Of course, there is a broad spectrum of policy responses—one that includes fiscal as well as monetary policy—that could be used to mitigate the effects of an exogenous price shock. Model simulation could also be used to study the mitigating effect of these policy responses, but this kind of analysis is beyond the scope of this article.

Price shock cases

Simulations with the BEA model were run for seven cases, designated by the name of the price that is shocked. The first three cases relate to increases in the prices of primary commodities or basic materials. The remaining four cases relate to increases in the prices of final products. Except in case 4, price increases are for specific commodities (or commodity groups) or services; these increases therefore result (at least initially) in relative price changes. In case 4, the price increase is for goods and services in general (represented by simultaneous increases in final-product deflators). The final three cases relate to specific final products with differing elasticities of demand or impacts upon wage rates and are designed to study the macroeconomic effects of these factors.

In order to indicate the sensitivity of results to different economic environments and to different assumptions about monetary accommodation, alternative simulations were run for

case 1 with accommodating monetary policy, using the high-unemployment control solution, and with and without accommodating monetary policy, using the low-unemployment control solutions.

Case 1. Price of domestic crude oil.—To reflect an increase in the price of domestic oil, the producer price index (PPI) for refined petroleum was increased about 21 percent above corresponding control solution levels.[17] Also, the PPI for electricity was increased 2.3 percent, an amount that reflects the small share of oil as a fuel source for electricity generation. Under an assumed long-run price elasticity of demand for oil of −0.25, the increase in the price of oil results in a reduced volume of oil imports (which are exogenous in the model).

Case 2. Price of primary iron and steel products.—The PPI for primary iron and steel products, an endogenous basic materials price, was increased about 23 percent.

Case 3. Price of farm products.—The PPI for farm products was increased 20 percent above corresponding control-solution levels. Because gross farm product and farm proprietors' income are explicit model variables, it is meaningful, in terms of the model structure, to assume that an autonomous reduction in farm output (and thus gross farm product) i.e., a supply shock—is the cause of the increase in farm prices. Specifically, associated with the increase in farm prices are an 11-percent decrease in real gross farm product and, in the first quarter of the simulation, a $2½ billion (1972 prices) decrease in farm inventory investment.[18] Underlying the decrease

14. For a full treatment of this issue, with definitions of extreme cases, see Edward M. Gramlich, "Macro Policy Responses to Price Shocks," *Brookings Papers on Economic Activity* (1979, 1): 125–66.

15. More precisely, because the case in point involves the price of the primary commodity (oil), the higher M2 level was phased in linearly over the first year, consistent with the gradual impact of the price change on the GNP deflator.

16. Initially, an interest-rate criterion of accommodation was considered. Specifically, a short-term interest rate was to be held at control solution levels, and thus the money supply was to be allowed to increase (endogenously) consistent with the stable interest rate and higher price levels. However, because it turns out that even with nonaccommodation, interest rates eventually fall below control-solution levels as a result of weakened economic activity, this criterion would actually have resulted in a lower money supply than in the control solution.

17. An increase in the price of domestically produced oil in the absence of a concomitant increase in the world price could occur, for instance, with decontrol. A comparable simulation was tried in which the price of imported oil was increased. Because the macroeconomic effects were on the whole very similar to those for the domestic oil price increase (with the main difference being that income is shifted abroad rather than from personal income to domestic corporate profits), the results of this variant are not reported here. A simultaneous change in domestic and foreign oil prices can also be expected to yield similar results.

An allowance was made for a lag in the pass-through of cost from crude to refined petroleum by raising the refined petroleum PPI only two-thirds the full pass-through amount in the first simulation quarter.

18. The temporary decrease in inventory investment results from the lack of an instantaneous market-clearing price response in wholesale and consumer markets for farm products.

in gross farm product is a 5½-percent decrease in farm output and a 2-percent decrease in intermediate products consumed. Farm proprietors' income increases an average of 60 percent, as increases in farm prices far outweigh production losses.[19]

Case 4. Implicit price deflators for final products.—All final product deflators, except those for imports and compensation of government employees, were increased about 1 percent. In addition to its main purpose, this simulation may be used to represent a stylized removal of price controls.

Case 5. Implicit price deflator for consumer purchases of new and net used automobiles.—This case illustrates the effects of shocking a deflator for a consumption component with a high price elasticity of demand, in this case -1.1. The deflator, which is basically endogenous, was exogenously increased 89 percent.

Case 6. Implicit price deflator for personal consumption expenditures for household operation, except gas and electricity.—This case illustrates the effects of a price shock for a consumption component with a low price elasticity of demand, -0.14. The deflator (which, again, is basically endogenous) was exogenously increased 43 percent.

Case 7. Implicit price deflator for investment in producers' durable equipment, except motor vehicles.—This case illustrates the effects of increasing the price of a nonconsumption component of GNP, which avoids a price-wage spiral. The deflator (also basically endogenous) was increased exogenously 14 percent.

Analysis of Results

In what follows, an analysis is first made of the principal simulations, i.e., the high-unemployment, nonaccommodating-monetary-policy (HU/NMP) simulations for all cases. Then, for case 1, low-unemployment (LU) and accommodating monetary policy (AMP) alternatives are compared with their HU and NMP counterparts.

Principal simulations

The analysis of the principal simulations proceeds as follows: (a) case 1—the domestic crude oil price shock—is used as a base case; (b) cases 2 through 4 are compared with case 1; and (c) cases 5 through 7, representing shocks to specific final product deflators, are compared with case 4 and with one another. Where other comparisons are of interest, they are also made. Tables 1.1 through 1.7 show, for the HU/NMP variants of cases 1 through 7, respectively, differences between price-shock and control-solution values for major economic variables at selected horizons (quarters) of the simulations. Chart 5 shows, for the same cases, the percent differences (price shock case less control solution) in the GNP deflator and in real GNP, respectively.

Case 1. Price of domestic crude oil.—The increase in the price of domestic crude oil results in gradual increases in the GNP deflator relative to the control solution. By the fourth quarter, the GNP deflator is 1.4 percent above the control-solution level and the difference continues to grow

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19. In the version of the model used for this study, farm output, prices, and income are all exogenous. Consistent relationships among them and between them and final demand for food and agricultural exports were derived by external calculation.

Table 1.1—Effects of Price Shocks: Case 1. Price of Domestic Crude Oil

[Differences: price shock less control solution]

	Quarters after change									
	1	2	3	4	6	8	10	12	14	20
Percent of control solution level										
GNP, constant dollars	-0.1	-0.5	-0.9	-1.2	-1.4	-1.6	-1.8	-1.9	-2.1	-1.9
Implicit price deflator, GNP	.5	.8	1.2	1.4	1.6	1.7	1.8	1.9	2.0	1.7
Implicit price deflator, personal consumption expenditures	.4	.8	1.0	1.1	1.3	1.4	1.5	1.6	1.7	1.5
Compensation per hour, nonfarm business sector except housing	0	0	.1	.2	.5	.5	.8	.9	.9	.8
Billions of dollars										
GNP	2.6	5.8	4.9	3.4	2.5	2.4	-.3	-1.2	-3.8	-6.7
Personal income	.1	1.1	.7	.4	1.1	.5	-1.6	-2.5	-5.7	-15.0
Corporate profits with IVA and CCAdj	2.9	5.8	6.5	5.4	4.2	3.5	3.2	3.3	7.1	14.2
Net exports of goods and services	-.8	1.9	5.2	7.3	9.4	9.2	9.4	9.9	11.0	9.8
Federal surplus or deficit, NIPA's	1.1	.9	-.8	-1.3	-1.5	-1.7	-2.0	-3.6	-4.7	-4.6
Billions of 1972 dollars										
GNP	-1.9	-6.1	-11.2	-15.6	-18.7	-21.9	-24.6	-26.5	-30.1	-28.8
Personal consumption expenditures	-1.5	-4.7	-7.6	-9.3	-8.4	-9.4	-11.6	-12.9	-15.4	-15.8
Nonresidential fixed investment	.4	.6	-.6	-2.4	-5.1	-6.4	-7.6	-8.2	-9.3	-8.7
Residential investment	-.2	-.9	-1.6	-2.2	-2.6	-2.5	-2.5	-2.4	-3.1	-.7
Change in business inventories	.1	-.1	-.9	-1.7	-2.4	-2.1	-2.1	-3.2	-1.7	-1.4
Net exports of goods and services	-.4	-.4	.1	.6	.7	.5	.9	.8	-.1	.1
Government purchases of goods and services	-.1	-.4	-.5	-.7	-.9	-1.0	-1.2	-1.3	-1.5	-1.4
Disposable personal income	-3.2	-6.1	-8.2	-9.7	-11.0	-12.3	-14.3	-16.7	-18.7	-21.4
Percent										
Share of national income:										
Compensation of employees	-.2	-.4	-.4	-.4	-.3	-.3	-.6	-.8	-.4	-.5
Proprietors' income with IVA and CCAdj	0	0	0	0	0	0	0	0	0	0
Corporate profits with IVA and CCAdj	.2	.4	.4	.4	.3	.2	.2	.2	.4	.7
Net interest	0	0	0	0	0	0	0	0	-.1	-.3
Rental income of persons with CCAdj	0	0	0	0	0	0	0	0	0	0
Unemployment rate	0	.1	.2	.3	.3	.4	.6	.7	.9	1.0
Yield, 4–6 month commercial paper	.4	.7	.5	.3	0	-.1	-.1	-.1	-.2	-.7
Yield, domestic corporate bonds (Moody's)	.1	.2	.2	.2	.2	.1	.1	.1	0	-.3
Quarterly change at annual rate:										
GNP, constant dollars	-.6	-1.4	-1.6	-1.4	-.3	-.5	-.6	-.1	-.2	.6
Implicit price deflator, GNP	1.2	2.1	1.5	1.3	.3	-.1	.1	.2	0	-.2

Note.—The abbreviations used in tables 1 and 2 are: CCAdj—capital consumption adjustment; GNP—gross national product; IVA—inventory valuation adjustment; NIPA's—national income and product accounts.

through the 16th quarter to 2.1 percent, then narrows slightly. Initially, the difference reflects the gradual pass-through of higher oil prices; later it increasingly reflects the interaction of the wage rate and consumer prices. The GNP deflator is up slightly more than the PCE deflator, mainly because there is a reduction in relatively high-priced oil imports. The oil price shock increases the inflation rate only temporarily; annual rates of increase in the GNP deflator are up more than 1 percentage point only during the first year. However, the price level remains substantially above the control solution over the whole simulation period, showing only a slight tendency to retreat toward it in the fifth year.

The higher price of oil and its secondary inflationary effects result in reductions in real GNP relative to the control solution of roughly the same magnitude. The decrease is largest—2.1 percent—in the 17th quarter, one quarter after the peak increase in the GNP deflator, and remains large thereafter. The rates of change in real GNP and in the GNP deflator move sharply in the quarters immediately following the price shock; then the differences from the control solution diminish rapidly to small amounts for the remainder of the period. This pattern is also typical for the cases that follow.

Higher prices relative to control solution of consumer oil products—gasoline and home heating oil—and of electricity (also due to the oil price increase) directly reduce consumer purchases of these energy products and also of motor vehicles, especially recreation vehicles. An increase in the PCE deflator relative to the control solution—the result of pass-throughs of higher oil prices to nonenergy as well as to energy products—also reduces real PCE, generally by lowering real disposable income and real household wealth. Compensation per hour is also higher and tends to hold down the reduction in real disposable income; however, it increases substantially less than the PCE deflator. The nonwage components of disposable income respond only slightly to the price increases. Employment is also down, tending to reduce labor income.

Initially, the decrease in real PCE relative to the control solution ac-

counts for most of the decrease in real GNP. After about a year, however, nonresidential fixed investment and inventory investment are down in response to the reduction in PCE. Both residential and nonresidential fixed investment are down because of higher long-term interest rates (see below). Government purchases are also down in response to the increases in the prices of noncompensation pur-

chases. Real net exports are up slightly after the second quarter, despite higher export prices, mainly because of the assumed reduction in oil imports. (Because of the relatively large deflator for oil imports, this difference is greatly magnified in current-dollar net exports.)

The unemployment rate is also up relative to the control solution, as lower output reduces employment. By

CHART 5

Effects of Price Shocks: Principal Simulations
(Price shock less control solution, relative differences)
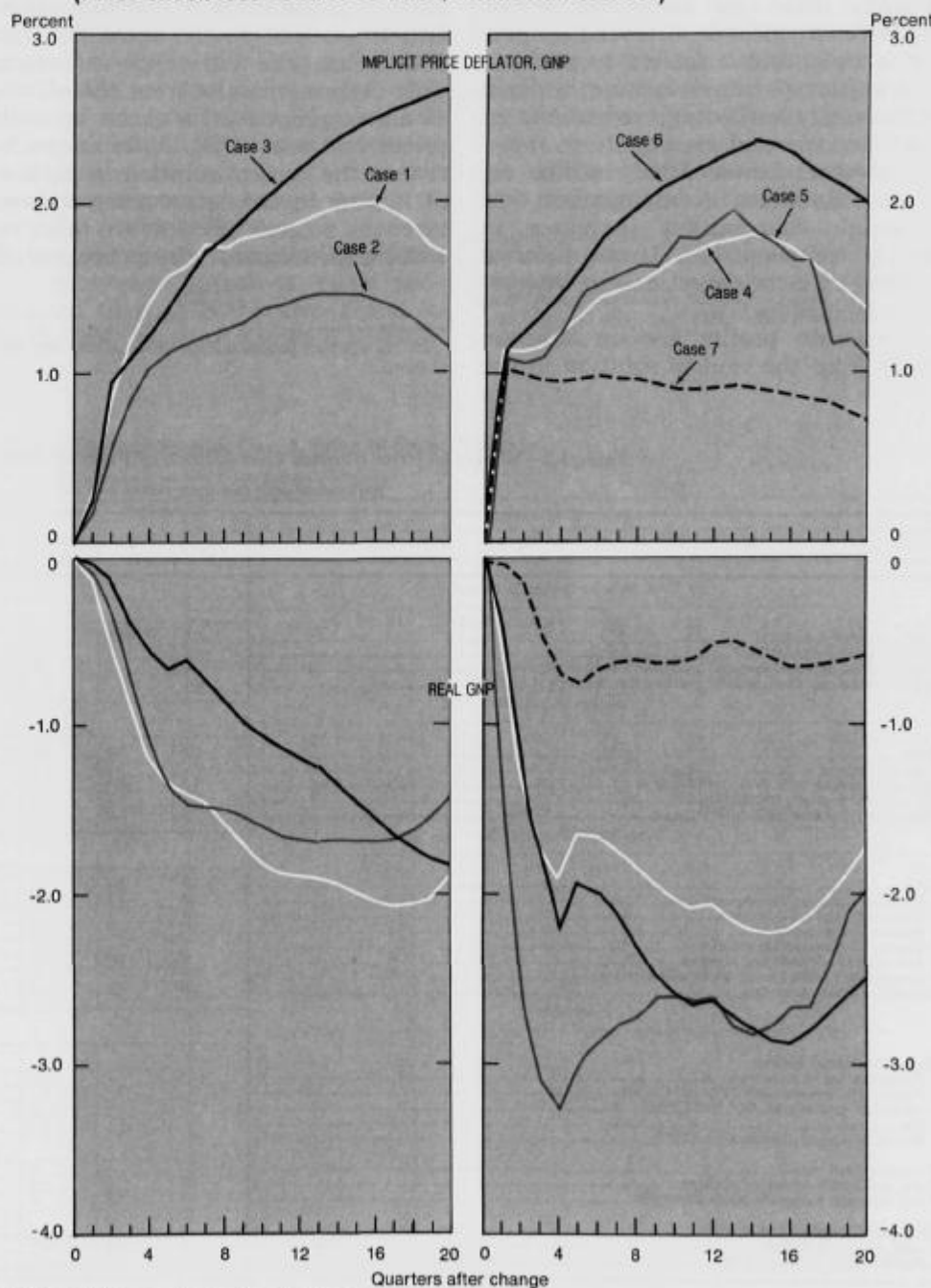
the 16th quarter, the rate is up nearly 1 percentage point and the spread continues to increase slightly thereafter, lagging the modest turnaround in the reduction in real GNP.

Current-dollar GNP is initially up slightly from the control solution, as the increase in the deflator more than offsets the decrease in real GNP; it is down in the 10th quarter and increasingly so thereafter, as the decreases in real GNP exceed the increases in the deflator.

Personal income is changed little from the control solution for about the first 2 years, as smaller wages are roughly offset by somewhat larger proprietors' income, dividends, interest income, and transfers to persons. Thereafter, personal income is down increasingly, reflecting reductions in labor income and eventually in interest income. Lower labor income reflects reductions in employment that outweigh concomitant increases in hourly compensation. Lower interest income reflects reductions in interest rates (see below).

Corporate profits are up substantially from the control solution in the early quarters, as higher oil prices are passed on to prices of final products.[20] The increase diminishes gradually from the third quarter to the middle of the period, as weakened demand tends to offset the price effect, then increases again as wage costs decrease. Shifts in shares of national income from employee compensation and net interest to corporate profits and, to a lesser extent, to proprietors' income are substantial by the end of the period.

The oil price shock increases the Federal deficit slightly in the first two years. In this part of the period, larger expenditures more than offset larger receipts. In the third through fifth years, the difference increases. This increase results from the effects of an exogenous price shock on both prices and real GNP. A decline relative to the control solution in personal income in the later quarters (centered in wages) holds down receipts, while expenditures are up because of

indexation and larger unemployment benefits.[21]

The yield on 4-to-6 month commercial paper, a representative short-term interest rate, is up significantly in the early quarters, as larger current-dollar GNP increases the demand for transactions balances in the face of a fixed money supply. In the eighth quarter, the difference in the commercial paper rate becomes negative and increasingly so thereafter. Differences in long-term rates, as exemplified by Moody's average corporate bond yield, lag substantially the differences in short-term rates.

Case 2. Price of primary iron and steel products.—The GNP deflator is up significantly less from corresponding control-solution levels in this case than in case 1. The maximum increase (reached in the 12th quarter) is 1.5 percent, compared with 2.0 percent in case 1. As might be expected,

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20. No windfall profits tax was assumed for this simulation.

21. Inflation *per se* tends to increase the Federal surplus (reduce the deficit). (See Frank de Leeuw and Thomas M. Holloway, "The High-Employment Budget: Revised Estimates and Automatic Inflation Effects," SURVEY, 62 (April 1982): 21–33.)

Table 1.2—Effects of Price Shocks: Case 2. Price of Primary Iron and Steel Products

[Differences; price shock less control solution]

	Quarters after change									
	1	2	3	4	6	8	10	12	16	20
Percent of control solution level										
GNP, constant dollars	-0.1	-0.3	-0.7	-1.1	-1.5	-1.5	-1.8	-1.7	-1.7	-1.4
Implicit price deflator, GNP	.2	.6	.9	1.0	1.2	1.3	1.4	1.5	1.4	1.1
Implicit price deflator, personal consumption expenditures	.1	.3	.6	.7	.9	1.0	1.0	1.1	1.1	.9
Compensation per hour, nonfarm business sector except housing	0	0	0	.1	.2	.3	.4	.5	.5	.3
Billions of dollars										
GNP	2.6	2.6	2.2	-1.8	-5.4	-4.8	-4.6	-5.5	-7.0	-8.3
Personal income	0	.3	-.9	-3.2	-3.6	-4.4	-5.4	-6.8	-10.1	-13.2
Corporate profits with IVA and CCAdj	1.6	2.5	1.7	-.9	-3.9	-2.8	-1.3	-.7	2.2	10.5
Net exports of goods and services	.8	.5	.8	1.7	2.7	2.4	2.3	2.5	2.6	2.5
Federal surplus or deficit, NIPA's	1.8	1.9	.9	-1.1	-3.4	-3.3	-3.1	-3.8	-4.4	-3.0
Billions of 1972 dollars										
GNP	-1.1	-4.4	-9.4	-14.6	-18.6	-20.1	-21.8	-23.4	-24.3	-21.6
Personal consumption expenditures	1.0	-3.1	-5.7	-7.8	-8.7	-8.7	-9.8	-10.0	-12.6	-11.9
Nonresidential investment	.4	.6	-.3	-2.1	-5.3	-5.8	-6.2	-6.7	-1.5	-6.9
Residential investment	-.2	-.7	-1.5	-1.7	-1.9	-1.8	-1.8	-1.8	-1.2	-.1
Change in business inventories	.1	-.3	-.7	-1.5	-2.7	-2.2	-1.8	-1.5	-1.2	-.6
Net exports of goods and services	.4	-1.0	-1.5	-1.1	-.8	-1.0	-1.5	-2.7	-2.0	-1.5
Government purchases of goods and services	-.1	-.2	-.2	-.3	-.4	-.4	-.5	-.5	-.7	-.6
Disposable personal income	-1.0	-2.8	-5.4	-7.5	-8.7	-9.7	-10.8	-12.0	-13.2	-14.1
Percent										
Share of national income:										
Compensation of employees	-.1	-.2	-.1	0	.1	.1	0	-.1	-.2	-.3
Proprietors' income with IVA and CCAdj	0	0	0	0	0	0	0	0	0	0
Corporate profits with IVA and CCAdj	.1	.2	.1	0	-.2	-.1	0	0	.2	.5
Net interest	0	0	0	0	.1	.1	0	0	-.1	-.3
Rental income of persons with CCAdj	0	0	0	0	0	0	0	0	0	0
Unemployment rate	0	.1	.2	.2	.4	.4	.5	.5	.7	.4
Yield, 4–6 month commercial paper	.3	.5	.4	.2	.4	-.1	0	-.3	-.3	-.7
Yield, domestic corporate bonds (Moody's)	.1	.1	.2	.1	.1	-.1	0	0	-.1	-.4
Quarterly change at annual rate:										
GNP, constant dollars	.4	-1.0	-1.6	-1.6	-.4	-.1	-.3	-.1	-.1	.5
Implicit price deflator, GNP	.9	1.5	1.3	-.8	.2	.2	.4	-.2	-.3	-.4

because of the high steel content of the commodities included, the final product deflators showing the largest relative increase are those for PCE for motor vehicles and for producers' durable equipment outlays. For consumer expenditures other than motor vehicles, the direct price effects are small. Thus, the spread between increases in the GNP and PCE deflators is greater than in case 1, in which the direct effects of the exogenous price increase are more widely dispersed among final products. As a result, the price-wage "spiral" is less pronounced than in case 1.

Nevertheless, real GNP is down about as much as in case 1 in the early quarters, although somewhat less in the later quarters. Nonresidential fixed investment is down substantially, in part because of the higher cost of investment goods. Similarly, the higher price of motor vehicles reduces consumer purchases. Moreover, total real PCE is held down by reductions in real disposable income that are almost as large as in case 1 through the 12th quarter, although,

as noted, the PCE deflator is up less than in case 1. Compensation per hour is also up less. Real net exports are down slightly, in contrast to case 1, in which oil imports are smaller.

Corporate profits are up only moderately in the first three quarters and down somewhat for about the next two years, in contrast to case 1, in which they are up continuously and more substantially. This contrast reflects both smaller current-dollar GNP and larger capital consumption allowances in case 2, the latter being due to higher capital replacement costs.

Case 3. Price of farm products.—In contrast to case 2, this price shock impinges heavily on the PCE deflator—specifically, on the deflator for consumer food purchases. It also increases substantially the deflator for merchandise exports, in which agricultural commodities have a weight of about 20 percent. Because of the concentrated impact on consumer prices, the price-wage spiral is more pronounced than in both cases 1 and 2. By the 12th quarter, the PCE deflator

is up 2.3 percent, compared with 1.6 percent in case 1 and 1.1 percent in case 2; the corresponding increases in the GNP deflator are 2.2 percent, 1.9 percent, and 1.5 percent; for private nonfarm compensation per hour, they are 1.5 percent, 0.9 percent, and 0.5 percent.

Despite the larger price increases, real GNP is down substantially less than in cases 1 and 2 during most of the simulation period—in the 12th quarter the loss is 1.2 percent, compared with 1.9 percent in case 1 and 1.7 percent in case 2.[22] The causes of this difference are the relatively low price elasticity of consumer demand for food (−0.36 in the long run) and, associated with this low elasticity, the substantial increase in farm proprietors' income, which offsets the reduction in real labor income. Because of this shift within personal income, total real disposable income and, as a

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22. In the first three quarters, especially the first, real net exports are too high because of a timing misspecification that affects the merchandise exports deflator. Accordingly, real GNP should be somewhat lower in those quarters.

Table 1.3.—Effects of Price Shocks: Case 3. Price of Farm Products

[Differences: price shock less control solution]

	Quarters after change									
	1	2	3	4	6	8	10	12	16	20
	Percent of control solution level									
GNP, constant dollars	0	−0.1	−0.4	−0.5	−0.6	−0.9	−1.1	−1.2	−1.6	−1.8
Implicit price deflator, GNP	.2	1.6	1.1	1.3	1.5	1.8	2.0	2.2	2.5	0.7
Implicit price deflator, personal consumption expenditures	.2	1.1	1.3	1.4	1.7	2.0	2.2	2.3	2.6	2.0
Compensation per hour, nonfarm business sector except housing	0	0	.2	.3	.5	.7	1.0	1.2	1.5	1.9
	Billions of dollars									
GNP	3.3	13.9	11.6	11.4	17.1	17.1	18.3	20.7	21.5	20.0
Personal income	11.8	14.1	14.3	15.2	19.5	22.2	24.9	29.9	34.2	38.7
Corporate profits with IVA and CCAdj	−8.8	.9	.3	−1.7	−1.2	−4.6	−5.5	−8.8	−11.9	−13.4
Net exports of goods and services	4.9	4.0	4.6	5.5	5.4	4.9	5.9	5.9	7.2	7.6
Federal surplus or deficit, NIPA's	−8.2	1.4	−.6	−1.3	0	−1.2	−1.7	−3.1	−5.5	−8.5
	Billions of 1972 dollars									
GNP	−.6	−1.6	−5.3	−7.4	−8.3	−11.5	−14.5	−16.8	−22.8	−27.5
Personal consumption expenditures	.7	−3.5	−5.9	−6.2	−4.1	−5.4	−4.5	−6.8	−9.4	−11.7
Nonresidential fixed investment	−.3	.3	1.1	.4	−1.1	−2.1	−2.4	−3.5	−5.1	−6.3
Residential investment	.1	−.5	−1.1	−1.3	−1.7	−1.9	−2.2	−2.1	−3.1	−3.6
Change in business inventories	−2.6	.7	.3	.5	−.8	−.7	−1.1	−1.3	−1.5	−1.9
Net exports of goods and services	2.1	.7	.7	.3	.9	−.3	−1.0	−1.5	−2.2	−2.4
Government purchases of goods and services	0	0	.6	−.1	−.3	−.5	−.5	−1.0	−1.5	−1.6
Disposable personal income	5.8	−.7	−2.0	−2.7	−4.0	−4.7	−6.5	−5.0	−7.5	−10.5
	Percent									
Share of national income:										
Compensation of employees	−.1	−.7	−.6	−.5	−.5	−.4	−.4	−.3	−.2	−.2
Proprietors' income with IVA and CCAdj	.8	.8	.7	.7	.7	.6	.6	.5	.3	.7
Corporate profits with IVA and CCAdj	−.7	0	−.1	−.2	−.2	−.4	−.4	−.6	−.7	−.3
Net interest	0	0	−.1	0	0	0	0	0	.1	.1
Rental income of persons with CCAdj	0	0	0	0	0	0	0	0	0	0
Unemployment rate	−.1	0	0	.1	.1	.2	.3	.4	.5	.7
Yield, 4–6 month commercial paper	.3	1.2	.3	.2	.3	.2	.3	.3	.3	.3
Yield, domestic corporate bonds (Moody's)	.1	.3	.2	.2	.3	.3	.3	.3	.4	.4
Quarterly change at annual rate:										
GNP, constant dollars	−.2	−.3	−1.1	−.7	.2	−.5	−.4	−.3	−.4	−.2
Implicit price deflator, GNP	1.0	3.0	.6	.5	.5	.3	.4	.4	.3	.1

result, real PCE are reduced much less than in the previous cases.[23]

By the 20th quarter, however, the decline in real GNP is as large as in case 1 and larger than in case 2. This catchup reflects primarily a large decrease in residential investment, which is in turn due to higher mortgage interest rates and a lower real return to owners of rental housing.

Increases in the unemployment rate are small during the first 3 years—0.4 percentage points by the 12th quarter compared with 0.7 percentage points in case 1 and 0.6 percentage points in case 2. A sizable share of the decreases in real GNP—during the first 3 years, about one-third on the average—is in gross farm product, to which there is no significant employment response. The smaller decrease in employment tends to hold up real wages.

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23. Contrary to the assumption (implicit in the model) that the marginal propensity to consume with respect to farm proprietors' income is the same as with respect to other personal income, a lower propensity might prevail if farmers viewed much of their income as not available for consumption, but rather as business income. If so, the difference between real GNP losses in this case and in cases 1 and 2 might be much smaller.

Because farmers, most of whom are unincorporated, are the beneficiaries of higher prices, their gains, together with larger employee compensation, squeeze the share of corporate profits. Because marginal tax rates on profits are high, the Federal fiscal balance eventually moves toward substantially larger deficits.

The increases in current-dollar GNP, in contrast to smaller increases or decreases in previous cases, together with a fixed money supply, yield short- and long-term interest rates that remain above control-solution levels, in contrast to lower rates in the previous cases. Higher interest rates contribute to weakness in residential and nonresidential fixed investment.

Case 4. Implicit price deflators for final products.—The macroeconomic effects of increasing final-product deflators proportionally are, in general, remarkably similar to those resulting from the domestic oil price shock. Because final-product prices are directly and immediately increased by the price shock in this case, increases in the GNP deflator and decreases in real GNP are larger in the early

quarters of the simulation than in case 1.

In the fourth quarter, although the PCE and GNP deflators are up roughly the same as in case 1, real GNP is down substantially more—9½ billion in 1972 dollars—than in case 1. More than one-half of the difference between the two cases in real GNP is due to nonresidential fixed investment, which responds to reduced cash flow as well as to earlier reductions in final sales. The impact on cash flow is from smaller corporate profits, which, in contrast, initially increase in case 1. In addition, real PCE is down $2.6 billion more than in case 1, mainly because of a larger reduction in employment, and inventory investment is down $1.7 billion more because of lower final sales.

After the fourth quarter, however, the difference between cases 1 and 4 in real GNP losses narrows quickly, as the lagged responses to the oil price shock are registered in case 1 and, more importantly, as the transitory effect of reduced cash flow terminates in case 4. By the 12th quarter, differences between the two cases in real GNP and unemployment, as well

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Table 1.4.—Effects of Price Shocks; Case 4. Implicit Price Deflators for Final Products

[Differences: price shock less control solution]

| | Quarters after change |
	1	2	3	4	5	6	10	13	16	20
	Percent of control solution level
GNP, constant dollars	-0.6	-1.2	-1.7	-1.9	-1.7	-1.8	-2.0	-2.1	-2.2	-1.7
Implicit price deflator, GNP	1.1	1.1	1.3	1.2	1.4	1.5	1.7	1.8	1.7	1.4
Implicit price deflator, personal consumption expenditures	1.2	1.2	1.2	1.3	1.5	1.6	1.7	1.8	1.5	1.5
Compensation per hour, nonfarm business sector except housing	0	.1	.3	.4	.6	.7	.9	1.0	1.0	.8
	Billions of dollars
GNP	6.6	-5.4	-10.2	-12.6	-4.5	-6.8	-8.8	-7.1	-12.2	-10.0
Personal income	.4	-.8	-2.5	-2.6	-.4	-1.8	-3.2	-3.6	-6.2	-17.0
Corporate profits with IVA and CCAdj	6.5	-.5	-7.0	-6.3	-3.6	-4.3	-3.8	-1.7	.4	12.5
Net exports of goods and services	-1.1	.4	3.0	2.6	1.7	1.7	2.1	3.4	2.1	2.2
Federal surplus or deficit, NIPA's	5.7	-2.7	-5.4	-5.4	-4.1	-4.9	-5.7	-5.6	-7.6	-4.5
	Billions of 1972 dollars
GNP	-7.2	-16.9	-23.4	-25.6	-23.1	-24.5	-27.5	-29.7	-32.3	-26.1
Personal consumption expenditures	-6.3	-11.3	-11.9	-11.9	-9.7	-11.4	-13.4	-14.6	-16.9	-15.9
Nonresidential fixed investment	1.8	-1.1	-5.1	-7.3	-6.6	-7.5	-8.2	-8.0	-10.3	-8.7
Residential investment	-.2	-2.1	-2.1	-2.0	-2.0	-1.8	-1.8	-1.8	-1.1	.5
Change in business inventories	.5	-1.2	-2.6	-3.4	-2.4	-2.1	-2.0	-2.1	-1.8	-.4
Net exports of goods and services	-2.0	-1.2	-.3	0	-.9	-.9	-1.1	-1.2	-1.0	-.6
Government purchases of goods and services	-.4	-.4	-.3	-.4	-.6	-.8	-.8	-1.0	-1.2	-1.0
Disposable personal income	-10.0	-10.8	-12.2	-13.1	-13.6	-14.9	-15.3	-16.0	-21.2	-22.5
	Percent
Share of national income:										
Compensation of employees	-.5	0	.3	.4	.1	.2	.1	0	-.1	-.4
Proprietor's income with IVA and CCAdj	0	0	0	0	0	0	0	0	0	0
Corporate profits with IVA and CCAdj	.5	0	-.4	-.5	-.2	-.2	-.2	-.1	.1	.3
Net interest	-.1	0	.1	.1	0	0	0	0	-.1	-.4
Rental income of persons with CCAdj	0	.1	.1	.1	.1	.1	.1	.1	.1	.1
Unemployment rate	.1	.3	.4	.4	.4	.5	.7	.8	1.0	1.0
Yield, 4-6 month commercial paper	1.8	-.1	-.1	-.1	0	0	-.1	-.2	-.5	-.8
Yield, domestic corporate bonds (Moody's)	.4	.1	.1	.1	.1	0	0	0	-.2	-.5
Quarterly change at annual rate:										
GNP, constant dollars	-2.6	-2.9	-1.7	-.8	0	-.4	-.4	.1	.1	.6
Implicit price deflator, GNP	4.3	0	.1	.4	.5	.3	.3	.3	-.2	-.4

as in the aggregate deflators, are small.

A difference persists, however, in real net exports, because of lower oil imports in case 1; the difference is magnified in current-dollar net exports because of the relatively high deflator for oil imports and, to a somewhat smaller degree, in current-dollar GNP and corporate profits. Lower current-dollar GNP results eventually in larger reductions in interest rates. Consequently, between the ends of the fourth and fifth years, there is more of a positive turnaround in real fixed investment and, accordingly, in the reduction in real GNP.

Two important conclusions can be derived from this analysis. First, an exogenous increase in the general price level—as distinct from an exogenous increase in the price of a particular commodity—is far from neutral in its impact on economic activity (i.e., on real GNP and employment). Although such a price increase produces, before output responses, a corresponding increase in current-dollar income, it results in a shift in income shares from those with a relatively

high propensity to spend to those with a relatively low propensity to spend. This shift, in turn, leads to a net reduction in real expenditures; the reduction in aggregate demand, which is reinforced by multiplier feedbacks, persists—as does the increase in the price level—with only a modest reversal of the reduction within the 5-year simulation period.

Second, some relative price increases, such as an increase in the price of crude oil, have effects similar to that of a general price level increase. This similarity reflects the widespread intermediate and end uses of these commodities and limited substitutability of lower priced alternatives.

Case 5. Implicit price deflator for consumer purchases of new and net used automobiles.—Real GNP is down more and unemployment is up more from the control solution in this case than in any other. By the fourth quarter, with a 1.3-percent increase in the GNP deflator—about the same increase as in case 4—real GNP is down 3.3 percent, compared with 1.9 percent in case 4, and unemployment is

up 1.3 percentage points, compared with 0.4 percentage points in case 4.

The price shock results directly in a large reduction in real auto purchases. This reduction, together with that in real disposable income resulting from both the higher overall PCE deflator and lower employment, reduces real PCE generally and both nonresidential fixed investment and inventory investment. A sharp initial falloff in corporate profits reinforces the reduction in nonresidential fixed investment. Net exports are up somewhat because of lower imports.

The reduction in real GNP begins to moderate in the fifth quarter, primarily because of a sudden dropoff in the inflation rate, as measured by the four-quarter change in the PCE deflator—a variable that has a substantial negative effect on total real PCE. Moderations in the reductions in other GNP components accompany or follow that in PCE. Although the reduction in GNP is smaller than in the fourth quarter, it remains large until the fifth year, as the price-wage spiral results in continuing increases in the PCE deflator. In the fourth year,

Table 1.5—Effects of Price Shocks: Case 5. Implicit Price Deflator for Consumer Purchases of New and Net Used Automobiles

[Differences: price shock less control solution]

	Quarters after change									
	1	2	3	4	6	8	10	12	16	20
	Percent of control solution level									
GNP, constant dollars	−1.6	−2.6	−3.1	−3.3	−2.9	−2.7	−2.6	−2.6	−2.7	−3.0
Implicit price deflator, GNP	1.1	1.1	1.1	1.3	1.5	1.6	1.5	1.9	1.7	1.1
Implicit price deflator, personal consumption expenditures	1.6	1.5	1.7	1.6	2.2	2.3	2.4	2.5	2.3	1.5
Compensation per hour, nonfarm business sector except housing	.6	.1	.3	.4	.7	.9	1.0	1.1	1.1	.5
	Billions of dollars									
GNP	−7.2	−27.0	−34.9	−53.5	−25.2	−21.5	−16.7	−16.3	−24.5	−24.4
Personal income	−4.8	−9.1	−14.3	−16.7	−12.0	−12.1	−11.0	−11.8	−18.9	22.2
Corporate profits with IVA and CCAdj	−.7	−11.6	−14.6	−13.4	−6.4	−9.3	.6	2.6	4.2	20.9
Net exports of goods and services	−.4	3.4	4.4	5.1	2.9	1.9	.3	.6	1.6	.6
Federal surplus or deficit, NIPA's	1.5	−11.8	−14.1	−14.7	−11.1	−9.2	−7.1	−7.0	8.6	−4.7
	Billions of 1972 dollars									
GNP	−19.6	−34.0	−40.1	−43.0	−36.1	−34.3	−35.1	−36.3	−35.6	−29.6
Personal consumption expenditures	−18.6	−24.7	−26.0	−25.4	−21.3	−20.0	−20.1	−21.3	−23.6	−22.9
Nonresidential fixed investment	.6	−4.1	−8.6	−11.5	−11.6	−11.8	−10.7	−10.0	−12.3	−9.4
Residential investment	−.6	−1.5	−1.2	−1.1	−1.1	−.9	−.8	−.3	.4	2.5
Change in business inventories	.3	−4.7	−5.9	−4.6	−4.4	−2.5	−1.7	−1.7	−1.7	.4
Net exports of goods and services	−.5	.7	1.9	2.6	.6	−.4	−1.1	−1.6	−.5	.4
Government purchases of goods and services	0	.1	.1	0	−.3	−.6	−.6	−.7	−.9	−.6
Disposable personal income	−16.9	−19.4	−25.0	−25.6	−29.6	−26.7	−27.1	−28.2	−29.4	−30.8
	Percent									
Share of national income:										
Compensation of employees	.6	.5	.6	.6	.2	.1	−.1	−.1	−.1	−.6
Proprietors' income with IVA and CCAdj	.6	.6	0	0	0	0	0	0	0	0
Corporate profits with IVA and CCAdj	.6	−.7	−.8	−.7	−.3	−.2	.1	.2	.3	1.1
Net interest	.6	.1	.2	.2	.1	0	−.1	−.2	−.3	−.6
Rental income of persons with CCAdj	0	0	.1	.1	0	0	0	0	0	0
Unemployment rate	.3	.8	1.1	1.3	1.1	1.1	1.2	1.3	1.4	1.3
Yield, 4–6 month commercial paper	1.3	−.4	−.4	−.3	−.3	−.3	−.1	−.2	−.7	−1.2
Yield, domestic corporate bonds (Moody's)	.2	0	0	0	−.1	−.1	−.1	−.2	−.4	−.8
Quarterly change at annual rate:										
GNP, constant dollars	−6.5	−4.6	−1.9	−.8	.6	.1	.1	.1	.5	.6
Implicit price deflator, GNP	4.7	−.2	.2	.6	.2	.2	.7	.4	−.1	−.6

higher unemployment rates reduce the wage-rate increases. This effect, together with higher productivity and a substantial reduction in long-term interest rates, reduces the increase in the PCE deflator, which in turn reduces the decrease in real GNP from 2.7 percent in the 16th quarter to 2.0 percent in the 20th.

Corporate profits are down sharply in the early quarters in response to the reduced demand. After widening through the fourth quarter, the difference relative to the control solution narrows sharply. In the 10th quarter, the difference becomes positive and by the 20th quarter, profits are up nearly $21 billion, although current-dollar GNP is down more than $24 billion. The large increase in profits toward the end of the period is mainly due to large reductions in employee compensation and net interest.

Case 6. Implicit price deflator for personal consumption expenditures for household operation, except gas and electricity.—Because of the much lower price elasticity of demand for household operation services than for automobiles, real PCE for household

operation is reduced by much smaller amounts than are automobile purchases in case 5. As a result, total real PCE and real GNP are reduced substantially less during the first two years after the price shock than in case 5 and unemployment rises less.

The smaller increase in unemployment, however, produces a smaller offset to the effect of the higher PCE deflator on compensation per hour; thus the price-wage spiral is stronger. By the 12th quarter, compensation per hour is up 1.6 percent compared with 1.1 percent in case 5. Smaller reductions in employment also tend to hold up real disposable personal income and thus real PCE. Nevertheless, because the PCE deflator is also up more, tending to reduce both real disposable personal income and real household wealth, real PCE is down as much in case 6 as in case 5 by the 16th quarter. Moreover, with the money supply fixed, smaller reductions in current-dollar GNP (reflecting the higher GNP deflator) eventually result in higher long-term interest rates, which tend to depress fixed investment. Thus, after 3 years, re-

ductions in real GNP are somewhat larger than in case 5.

Because this case is comparable to case 3 in the sense that the price shock impinges on a PCE component with a relatively low price elasticity of demand, similar macroeconomic results might be expected (apart from a short-run timing difference, due to the lagged pass-through of farm prices). The price effects are, indeed, roughly similar after the first year. However, real GNP is down more than in case 3 because of a stronger shift of income shares from personal income to corporate profits; in case 3, the shift is to proprietors' income, with respect to which the propensity to consume is (in the model) as large as with respect to other personal income.[24]

Case 7. Implicit price deflator for investment in producers' durable

24. The qualification expressed in footnote 23 concerning the realism of this relatively high propensity also applies to the comparison of cases 3 and 6. Further, the difference between cases 5 and 6 in PCE responses overstates those that would actually occur to the extent that cross-elasticities of demand are understated in the model.

Table 1.6.—Effects of Price Shocks: Case 6. Implicit Price Deflator for Personal Consumption Expenditures for Household Operation, Except Gas and Electricity

[Differences: price shock less control solution]

	Quarters after change									
	1	2	3	4	6	8	10	12	16	20
	Percent of control solution level									
GNP, constant dollars	-0.4	-1.3	-1.9	-2.3	-3.0	-2.3	-2.6	-2.7	-2.9	-2.4
Implicit price deflator, GNP	1.3	1.2	1.4	1.5	1.8	2.0	2.1	2.3	2.3	2.0
Implicit price deflator, personal consumption expenditures	1.7	1.8	2.0	2.1	2.4	2.5	2.6	2.7	2.3	2.5
Compensation per hour, nonfarm business sector except housing	0	0	0	.6	1.0	1.2	1.4	1.6	1.5	1.4
	Billions of dollars									
GNP	11.7	-1.2	-9.4	-15.7	-4.8	-6.8	-10.6	-9.5	-15.1	-18.3
Personal income	1.2	1.9	-.2	-1.3	1.5	0	-8.8	-8.1	-10.4	-21.1
Corporate profits with IVA and CCAdj	11.4	1.6	-5.7	-3.7	-2.6	-9.0	-8.4	-1.3	1.3	16.4
Net exports of goods and services	-3.3	-.9	1.8	2.8	1.8	1.5	2.4	2.3	3.1	2.9
Federal surplus or deficit, NIPA's	7.6	-3.0	-6.6	-8.7	-5.8	-6.8	-8.5	-6.3	-10.1	-6.5
	Billions of 1972 dollars									
GNP	-5.7	-18.1	-24.4	-29.1	-26.5	-30.4	-35.8	-36.9	-41.7	-35.1
Personal consumption expenditures	-5.5	-12.4	-14.4	-16.6	-12.6	-15.1	-13.4	-19.9	-24.4	-23.5
Nonresidential fixed investment	2.8	-.8	-5.1	-7.9	-7.7	-9.1	-10.4	-10.3	-12.8	-11.4
Residential investment	-.7	-1.9	-2.1	-2.1	-2.1	-2.0	-2.0	-1.9	-1.1	-.6
Change in business inventories	.2	-.3	-2.6	-3.6	-2.8	-2.6	-2.8	-2.7	-2.3	-.9
Net exports of goods and services	-3.0	-1.3	-.4	.2	-.8	-.6	-.8	-.9	-.8	-.4
Government purchases of goods and services	0	0	0	-.1	-.4	-.8	-1.0	-1.1	-1.2	-1.2
Disposable personal income	-14.8	-24.4	-17.2	-18.7	-19.3	-21.9	-24.6	-25.1	-30.3	-34.2
	Percent									
Share of national income:										
Compensation of employees	-.7	-.1	.2	.4	.1	.1	.2	0	-.1	-.4
Proprietors' income with IVA and CCAdj	0	.1	.7	0	.1	.1	.1	0	.1	.3
Corporate profits with IVA and CCAdj	.8	.1	-.3	-.5	-.1	-.2	-.2	-.1	.1	.5
Net interest	-.1	-.1	.1	.1	0	0	0	-.1	-.2	-.5
Rental income of persons with CCAdj	0	0	0	0	0	0	0	0	.1	0
Unemployment rate	.1	.3	.4	.5	.6	.6	1.1	1.3	1.4	1.4
Yield, 4-6 month commercial paper	1.6	0	-.3	-.1	-.1	-.1	-.3	-.3	-.6	-1.1
Yield, domestic corporate bonds (Moody's)	.4	.1	.2	.1	.1	.1	0	0	-.3	-.6
Quarterly change at annual rate:										
GNP, constant dollars	-1.4	-3.5	-2.4	-1.4	-.1	-.7	-.6	.1	0	.6
Implicit price deflator, GNP	4.9	.4	.5	.6	.8	.8	.2	.3	-.2	-.1

equipment, except motor vehicles.—A relatively low price elasticity of demand—in the long run, about —0.3—attaches to investment in producers' durable equipment. The endogenous responses in this case are much smaller than in any of the previous cases. Because the exogenous price increases is for a nonconsumption component of GNP, so that there is only a very small feedback to the PCE deflator, reductions in real disposable income and real household wealth, and thus, in PCE, are small. Together with the small increases in the PCE deflator, increases in unemployment, although modest, virtually prevent a price-wage spiral.[25]

An initial step-up in cash flow raises nonresidential fixed investment above the control solution in the first and second quarters. By the third

quarter, however, the difference is negative. PCE is again the real GNP component showing the largest absolute decrease from the control solution; reductions in real household wealth as well as the reductions in real disposable income contribute to this effect.

Varying the economic and policy environment

The results presented thus far have been for a HU/NMP environment. The effects of varying the unemployment rate in the control solution and the assumed monetary policy response in the shocked solution will now be examined, using case 1 for illustration (see table 2 and chart 6).

The results for case 1 are illustrative of all of the price shock cases reported in the sense that they indicate the direction and, for many of the cases, the order of magnitude of the differences in results due to the effects of varying the unemployment rate and the monetary response. It cannot be assumed, however, that the differences would be of even approxi-

mately the same magnitude for all the cases.

Low-unemployment control solution.—In both the LU/NMP and HU/NMP cases, the differences from the control solution in real GNP and the GNP deflator are about the same for the first six quarters.[26] After that, however, the differences begin to diverge. Because of the nonlinear relationship between changes in the wage rate and the level of unemployment, an increment to the unemployment rate of a given size that results from a positive price shock has a substantially more mitigating effect on compensation per hour when that increment is added to a base unemployment rate of 5½ to 6 percent (LU) than when it is added to a base rate

25. The reason that the PCE deflator increases at all is that changes in the general price level appear as explanatory variables in some PCE component deflator equations. Their appearance is, perhaps, a misspecification in the present context. On the other hand, there may be an offsetting specification error in that nonconsumption prices do not appear as an explanatory variable in the wage-rate equation.

26. The slight differences are hard to account for, but are probably mainly due to the small differences in the historical periods used in the control solutions.

The sizable differences in interest-rate effects (as represented by the yield on commercial paper) are due to the fact that interest rates in the initial quarter of the LU control solution are almost twice as high as the corresponding rates in the HU control solution. The larger absolute differences in rates reflect comparable relative differences (note that the interest rates in the money demand equation are expressed in logarithmic form).

Table 1.7.—Effects of Price Shocks: Case 7, Implicit Price Deflator for Investment in Producer's Durable Equipment, Except Motor Vehicles

[Differences: price shock less control solution]

	Quarters after change									
	1	2	3	4	6	8	10	12	16	20
Percent of control solution level										
GNP, constant dollars	-0.1	-0.5	-0.7	-0.8	-0.6	-0.6	-0.6	-0.5	-0.7	-0.5
Implicit price deflator, GNP	1.0	1.0	1.0	1.0	1.0	1.0	.9	.9	.9	.7
Implicit price deflator, personal consumption expenditures	.3	.2	.2	.3	.4	.4	.4	.4	.3	.2
Compensation per hour, nonfarm business sector except housing	0	0	.1	.1	.1	.2	.2	.2	.1	0
Billions of dollars										
GNP	14.1	9.0	4.5	2.0	6.8	6.1	5.9	5.5	4.7	4.5
Personal income	1.0	.2	-1.1	-1.5	-.8	-1.2	-1.5	-.8	-3.9	-7.5
Corporate profits with IVA and CCAdj	5.8	1.7	-3.1	-4.2	-1.5	-2.1	-1.9	-.5	-2.3	-.3
Net exports of goods and services	-2.2	-1.7	-.9	-.3	1.0	-1.8	-1.8	-1.3	-1.8	-1.3
Federal surplus or deficit, NIPA's	3.1	2.7	.6	.1	1.7	1.7	1.4	1.4	2.6	2.0
Billions of 1972 dollars										
GNP	-1.6	-5.9	-9.1	-10.2	-8.2	-8.4	-8.3	-6.9	-9.7	-8.2
Personal consumption expenditures	-1.5	-3.5	-3.8	-3.5	-2.9	-3.6	-3.7	-3.5	-5.8	-4.7
Nonresidential fixed investment	2.5	.8	-1.3	-2.0	-1.7	-1.8	-1.5	-.2	-2.0	-2.0
Residential investment	-.6	-1.7	-1.6	-1.7	-1.6	-1.4	-1.3	-1.3	-1.2	.8
Change in business inventories	.1	-.1	-1.0	-1.5	-1.0	-.7	-.6	-.4	-.5	-.2
Net exports of goods and services	-1.3	-1.4	-.9	-.6	-1.0	-.9	-.3	-1.1	-.3	-.5
Government purchases of goods and services	0	0	0	0	-.1	-.1	-.1	-.1	-.1	0
Disposable personal income	-2.1	-2.7	-3.5	-3.8	-3.8	-4.6	-4.6	-3.7	-5.6	-5.3
Percent										
Share of national income:										
Compensation of employees	-.3	-.1	.1	.2	0	.1	.1	0	0	0
Proprietors' income with IVA and CCAdj	0	0	0	0	0	0	0	0	0	0
Corporate profits with IVA and CCAdj	.4	.1	-.2	-.3	-.1	-.1	-.1	0	-.1	0
Net interest	0	-.1	.1	.1	-.1	.1	.1	.1	-.1	0
Rental income of persons with CCAdj	0	0	0	0	0	0	0	0	0	0
Unemployment rate	.1	.1	-.1	.2	.1	.2	.2	.2	.1	.8
Yield, 4-6 month commercial paper	1.5	.1	0	0	0	0	0	.1	-.1	-.2
Yield, domestic corporate bonds (Moody's)	.3	.1	.1	.1	-.1	.1	.1	.1	0	0
Quarterly change at annual rate:										
GNP, constant dollars	-.5	-1.3	-1.0	-.3	.2	0	-.1	.5	0	.2
Implicit price deflator, GNP	4.3	-.1	-.1	0	.1	-.1	-.1	.1	-.1	-.2

of 7½ to 8 percent (HU). Thus, the price-wage spiral is weaker than in the HU-based simulation.

The differences from the LU control solution in aggregate price level and compensation per hour begin to trend down in the third year; in the HU-based simulation, such a trend begins only in the fifth year. In the final quarter of the LU-based simulation, the GNP deflator is up only 0.7 percent, compared with its peak increase of 1.5 percent in the seventh quarter and 1.7 percent in the final quarter of the HU-based simulation; compensation per hour is actually down 0.5 percent, with the effect of higher unemployment on the wage rate dominating that of higher prices.

The smaller price increases in the LU-based simulation hold down the reduction in real GNP, which also eventually reverts toward zero. During the last half of the period, when the reductions tend to diminish, they are much smaller than in the HU-based simulation. The reduced price increases operate through higher real values of household financial assets, which hold down the reduction in PCE (real disposable income is down about the same in the two simulations), and through lower interest rates and larger profits,

which hold up fixed investment; also, the reductions in real government purchases are smaller. A larger shift in income shares from wages and interest to profits occurs in the LU-based simulation, another result of the greater sensitivity of wage rates to changes in unemployent.

It may seem paradoxical that a positive price shock is more self-limiting when it impinges on a high-employment economy, in which one might expect the potential for triggering accelerating inflation to be stronger, than when it impinges on a low-employment economy. The explanation is that a positive price shock, which is characterized in this article as a one-time exogenous step-up in a price or price level, has only a transitory inflationary impact. Fundamentally, it is deflationary, tending to lower demand and, eventually, prices. The deflationary effect is greater at a lower unemployment rate because of the nonlinearity in the response of wage rate changes to given shifts in the unemployment rate.

Monetary accommodation.—Again using the HU control solution and case 1, the AMP assumption of increasing M2 1 percentage point has virtually no effect on the aggregate price level during the first half of the

period and only a slight effect during the last half of the period. The reductions in real GNP are only slightly smaller, due to lower interest rates.

The differences between the AMP and NMP simulations are also small using the LU control solution. However, in the LU/AMP simulation, there are somewhat larger price responses relative to those in the LU/NMP sim-

CHART 6

Effects of Price Shock With Alternative Unemployment Rates and Monetary Responses: Case 1
(Price shock less control solution, relative differences)

U.S. Department of Commerce, Bureau of Economic Analysis
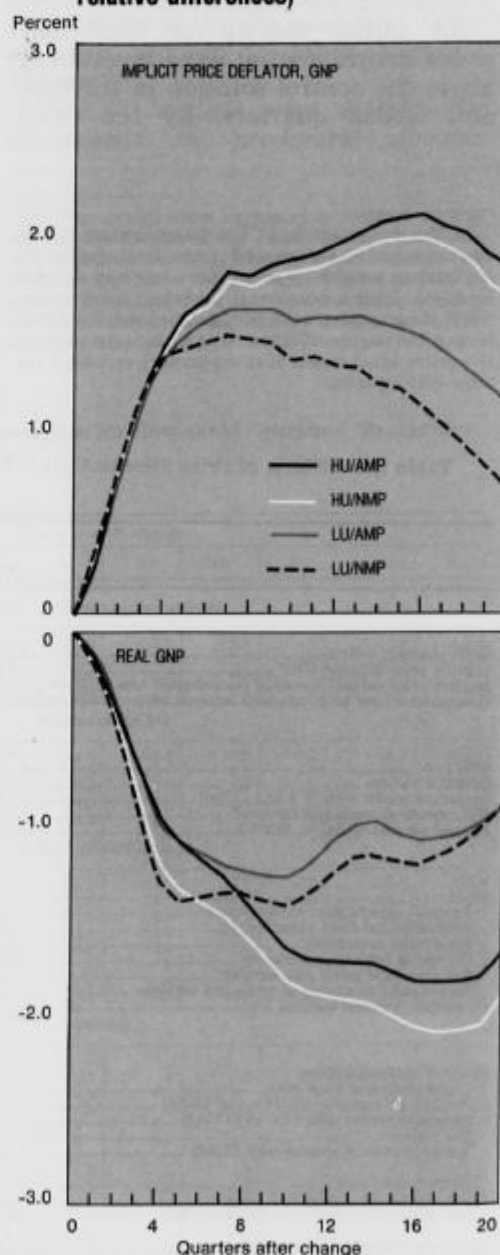
Table 2.—Effects of Price Shock with Alternative Unemployment Rates and Monetary Responses: Case 1

[Differences: price shock less control solution]

	Quarters after change									
	1	2	3	4	6	8	10	12	16	20
	Percent of control solution level									
Implicit price deflator, GNP:										
HU/NMP	0.3	0.8	1.2	1.4	1.6	1.7	1.8	1.9	2.0	1.7
HU/AMP	.3	.8	1.1	1.4	1.7	1.8	1.9	1.9	2.1	1.8
LU/NMP	.4	.8	1.0	1.1	1.2	1.4	1.3	1.3	1.1	.7
LU/AMP	.3	.8	1.1	1.4	1.6	1.6	1.6	1.6	1.5	1.1
GNP, constant dollars:										
HU/NMP	−.1	−.5	−.9	−1.2	−1.4	−1.6	−1.8	−1.9	−2.1	−1.9
HU/AMP	−.1	−.4	−.7	−1.0	−1.2	−1.4	−1.7	−1.7	−1.8	−1.7
LU/NMP	−.2	−.5	−.9	−1.3	−1.4	−1.4	−1.4	−1.3	−1.2	−.9
LU/AMP	−.1	−.4	−.7	−1.0	−1.2	−1.3	−1.3	−1.1	−1.1	−.9
	Percent									
Unemployment rate:										
HU/NMP	0	.1	.2	.3	.3	.4	.6	.7	.9	1.0
HU/AMP	0	.1	.1	.2	.3	.4	.6	.7	.8	.9
LU/NMP	0	.1	.2	.3	.4	.5	.6	.7	.7	.7
LU/AMP	0	.1	.2	.2	.3	.5	.6	.6	.6	.7
Yield, 4–6 month commercial paper:										
HU/NMP	.4	.7	.5	.3	0	−.1	−.1	−.1	−.2	−.7
HU/AMP	0	.2	0	−.2	−.1	−.2	−.2	−.3	−.4	−1.0
LU/NMP	.6	1.2	1.0	.6	−.1	−.2	−.2	−.4	−.6	−.9
LU/AMP	0	.4	.1	−.4	−.2	−.5	−.9	−.7	−.8	−1.2

ulation than in the HU/AMP simulation relative to the HU/NMP simulation, with noticeable differences in the GNP deflator appearing as early as the fourth quarter; by the end of the period, the deflator is 0.4 percent higher in the LU/AMP simulation than in the LU/NMP simulation, in contrast to a corresponding difference of only 0.1 percent in the HU-based simulations. There is less of a contrast between differences in real GNP responses—AMP versus NMP—when the LU- and HU-based simulations are compared. Toward the end of the period the differences are slightly smaller for the LU-based simulations, the result of the larger price differences. Although these differences are not large, they show that the demand stimulus created by the larger money supply has more inflationary impact in a high-employment than a low-employment economy, whereas, as noted earlier, a price shock itself has a more inflationary impact in a low-employment economy.

It may be noted that an accommodating monetary policy, as here defined, does not, even after 5 years, neutralize the effects on real output and employment of a price shock, and results in higher price levels. Although current-dollar GNP is larger in the AMP simulation than in the NMP simulation, the differences are not nearly enough to maintain constancy in the velocity of money. This implies that the money supply must be increased several times the amount required to accommodate the additional transactions demand engendered directly by the price shock in order to neutralize the effects on real output and employment.